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Objective and subjective assessments of normal walking pace, in comparison with that recommended for moderate intensity physical activity.

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ABSTRACT

Int J Exerc Sci 3(3): 87-96, 2010. Despite its common application and widely reported health benefits, walking, in relation to pace and intensity, is under-researched. Few studies have addressed whether people normally walk at a pace that meets the public health recommendations for moderate intensity physical activity (1.34-1.79 ms⁻¹) and there is no known research on individuals' perceptions of factors which influence walking pace. This study aimed to objectively assess if participants were reaching the pace required for moderate intensity physical activity during normal walking. This was examined via a Global Positioning System (GPS) over a 1 km outdoor walk and a timed 150 m trial. In both tests participants (n=10, 3 men, 7 women, mean age 54±8 y) were instructed to walk at their normal pace. Through short interviews, the study also investigated the factors that participants' thought influenced their pace. All participants successfully walked at a pace considered as moderate intensity (≥1.34 ms⁻¹). Height was significantly correlated with normal walking pace. The interviews provided an in depth insight into factors that affect walking pace; ground surface and footwear were mentioned frequently and the influence of the weather provided conflicting views, prompting a need for further research in the area. The GPS device showed enormous potential as a human locomotion measurement tool, enabling participants to walk unobstructed and unobserved in an outdoor setting, making the results relevant to real life situations.

KEY WORDS: exercise, everyday walking speed, environmental influences

INTRODUCTION

In order to enjoy the health benefits of physical activity (PA), it is recommended that adults accumulate a minimum of 30 minutes moderate intensity PA on a minimum of five days per week (12). Moderate intensity activities are defined as those with a metabolic equivalent of the task (MET) value of 3 to 6. This level of energy expenditure can be achieved by

walking between 1.34-1.79 ms⁻¹ (3-4 mph) (23). Public health agencies have established that brisk walking can be counted towards the recommended 30 minutes (12).

The rhythmic activity of walking uses large skeletal muscle (21) and is one of the most common repetitive movements that humans perform (30). Walking is self-regulated in intensity, duration and

frequency and is intrinsically safe, due to the low ground impact (6). Additionally, it is now widely recognized that regular walking can have many beneficial effects including improved lipid profiles, decreased blood pressure (15), and adiposity (7), positive changes in aerobic capacity (22) and improved psychological well being (1). Brisk walking specifically has also been linked with a number of favorable health outcomes, including decreased risk of type 2 diabetes (14), increases in serum concentrations of high density lipoprotein (HDL) cholesterol (11) and reductions in the incidence of coronary heart disease and cardiovascular events in women (18). The hazards of slower walking speeds have also been highlighted. McGinn et al. (20) found that slower walking speeds were a strong predictor of increased risk of ischemic stroke among postmenopausal women, and this association persisted after multivariate adjustment for known stroke risk factors and other variables associated with walking speed such as age, height and BMI and other physical functioning variables.

Despite its common application and widely reported health and fitness benefits, it is surprising that walking, in relation to quantity, pace and intensity, is under-researched, particularly in middle aged and older adults (21). Few studies have addressed whether people habitually walk at a pace that meets the public health recommendations for moderate intensity exercise (23). Murtagh et al. (23) investigated the walking pace of 82 adult recreational walkers by covertly observing them in a public park. In this study, it was found that the walkers were selecting a pace and intensity that met current moderate intensity physical activity recommendations. Pollock et al. (27 & 28) established that most healthy adults are capable of reaching moderate to vigorous exercise intensities whilst walking. Spelman

et al. (29) reported that self-selected exercise intensity of unsupervised free-living exercise walkers was $1.78 \pm 0.19 \text{ ms}^{-1}$, with a metabolic cost $5.2 \pm 1.2 \text{ METs}$. This is toward the higher end of MET values required for moderate intensity exercise. As an individual's physiological stress related to walking speed is a function of $\text{VO}_{2\text{max}}$ (29), it was unsurprising that the walking speeds observed in Murtagh et al. (23) were slower than Spelman et al. (29); as they observed recreational and exercise walkers respectively. Murtagh et al. (23) also established that instructing individuals to "walk briskly" prompted more vigorous activity. However, their study measured exercise intensity on a treadmill, which may not truly reflect walking on an outdoor surface, as an uneven outdoor terrain can increase the energy cost of walking by $\sim 10\%$ (25).

Over the last ten years, an increasingly popular method of assessing walking in free-living conditions is the Global Positioning System (GPS) and it has been recognized as a precise and efficient method of determining an individual's walking speed (30 & 33). New GPS devices allow an average speed accuracy of 0.03% (0.000402 ms^{-1} for an individual walking at 1.34 ms^{-1}), which is comparable with the accuracy that a photoelectric system can provide (26). Compared with accelerometers, GPS have several potential advantages for studying outdoor walking, by permitting direct position estimation, measurements of ground slopes, the calculation of speed without individual calibration before use (17) and providing the user with freedom in the choice of walking style. New devices are user-friendly, relatively low-cost and small in size (17). Testing using GPS can therefore be considered closer to an actual physiological situation than current laboratory treadmill experiments (26).

From the literature, it is clear that the pace of walking is not determined by any one factor, but a combination of influences. Although some of the underlying physiological mechanisms are still unclear, the speed of walking appears to decline with age (9). This may be due to cardiovascular fitness (5 & 19). Generally, height is positively correlated with walking speed (13). Consistently, faster walking speeds are observed in males compared to females, which may reflect different step lengths and step frequencies (13). Additionally, several environmental and individual factors have been reported to affect the speed of walking. These include with whom the individual is walking (8 & 16), whether the individual was accompanied by a dog (32), and pavement pedestrian density whilst walking (2). Walking speed may also be determined by unobservable factors such as motivation and purpose for walking (8).

From the populations studied to date, it would appear that adults are walking at speeds, which meet moderate intensity physical activity recommendations. However, these results may not accurately represent the general adult population. Previous studies have focused on relatively young study participants, habitual walkers, and active participants or have used a treadmill to assess intensity, thus limiting the ability to generalize the findings. The purpose of this study therefore was to objectively assess if the walking pace low active men and women in Scotland select, when asked to walk at their normal pace, is sufficient to meet moderate intensity physical activity guidelines.

METHODS

Experimental Design and Ethical Approval

Ethical approval was obtained from the University of Strathclyde ethics committee. Testing was conducted on the university

campus and comprised of three parts; a walk around the campus grounds at the participant's normal walking pace whilst wearing a GPS unit called a Trackstick II TM, referred to as GPS tracked walk (Part one), three 150 m time trials which were conducted at the participant's slower than normal pace, normal pace and faster than normal pace (Part two) and an interview relating to the participant's walking pace (Part three). Participants were tested individually. Parts one and two of the testing took place outdoors and part three indoors.

Participants

Participants were recruited from a large-scale ongoing research study within the department called Walking for Wellbeing in the West. The full methodology for the Walking for Wellbeing in the West study is available from Fitzsimons et al. (10). Participants of the Walking for Wellbeing in the West study were approached by a member of the research team and asked if they would like to take part in an additional research study exploring walking pace. Participants were approached by a member of the study team and accepted on a first come basis. Written informed consent was taken on visit one.

Testing Procedures Part 1: 1 km GPS tracked Outdoor walk

Participants were asked to walk at their normal pace around a defined 1 km circuit in the university grounds, which had a mixed terrain of concrete and grass. The Trackstick II TM was attached to their collar and they began their walk on the investigator's instruction. The duration of the walk was recorded on a stopwatch. The participants completed the route unaided and unobserved and could stop to rest during it if they wished. Previous work has suggested that three minutes rest is sufficient for recovery after walking (9), however to ensure the participants had

fully recovered from the 1 km walk and to minimize fatigue, the rest time between part one and part two of testing was five minutes. Prior to beginning part two, participants were also asked for their rate of perceived exertion (RPE), measured on the 15-point scale (3) to confirm that they had fully recovered.

Testing Procedures Part 2 - 150 m Time Trials

Part two of the testing took place on level concrete ground within the university campus. Participants were asked to walk for 150 m at three speeds; slower than normal pace, normal pace and faster than normal pace. Markers were set 50 m apart and the participants were instructed to walk between the markers three times. The order of walking speeds was randomly assigned. Each trial started from the same marker on the investigator's instruction and there was a 3-min rest period between each trial. Immediately after completing each trial, participants were asked for their RPE. The time taken to cover the 150 m was recorded on a stopwatch and the walking pace was then calculated. Participants were not made aware of their paces following each trial.

Testing Procedures Part 3- Subjective assessment of participant's perceptions of their walking pace and influencing factors

The participants gave verbal permission to be recorded using a mini disc Dictaphone recorder (Sony MZ-B100 Dictaphone) during their interview, which lasted 5-10 minutes. They were asked to comment on parts one and two of the testing and then asked the following questions: 1) "Do you think about the pace that you walk at?", 2) "How do you feel when you are walking in terms of your body's physical responses?", 3) "How would you describe your walking pace?", and 4) "What sort of things may influence your walking pace?"

Statistical Analysis

All statistical analyses were carried out using SPSS® (v15.0; Chicago, IL). For all tests statistical significance was established at $p < 0.05$. Descriptive statistics were computed for the four walking paces (the GPS tracked walking pace and the three time trial paces). These were compared graphically to the minimum pace recommended for the accomplishment of moderate intensity physical activity (1.34 ms^{-1}) (Figure 1). The four walking speeds were compared using a single-factor within-subject repeated measures ANOVA to determine significance. To assess the association between the normal pace and the GPS tracked pace and the explanatory variables; age, height, weight, BMI, percentage body fat and 12 month step count, Pearson's correlation and the significance associated with the correlation coefficients were examined. The walking speeds of male and female participants were compared using an independent *t*-test.

Subjective Analysis

Interviews were audio recorded, transcribed verbatim, and thematically analyzed. Thematic analysis was completed by coding participants' responses into categories that summarized and systemized the content of the data. Following the technique described by Thomas et al. (31), initial codes were then identified. This was done through careful reading and re-reading of the data and constant comparison. These codes were then categorized into themes by the lead investigator, and then checked by the other authors. These were then conceptualized into a visual representation of the themes that emerged into a spider diagram (Figure 2).

RESULTS

Objective assessment results

Participant characteristics are outlined in Table 1. All participants completed the three parts of testing. Anthropometric data was collected as part of the larger Walking for Wellbeing in the West study. For full methodology of how the anthropometric variables were assessed see Fitzsimons et al. (10).

Table 1: Characteristics of Study Participants

	All	Female	Male
N	10	7	3
Age, years	54 ± 8	55 ± 6	51 ± 13
Height (m)	1.66 ± 0.06	1.63 ± 0.06	1.71 ± 0.03
Body mass (kg)	81.23 ± 17.59	80.00 ± 20.54	84.10 ± 10.45
% Body Fat	32.55 ± 5.73	35.87 ± 1.82	24.83 ± 3.14
Daily Step Count	12,547 ± 3,574	11,596 ± 3,061	14,766 ± 4,341
BMI (kg/m ²)	29.67 ± 6.52	30.13 ± 7.78	28.60 ± 2.70

Values represent mean ± SD

The participants' mean RPE values following the slower than normal, normal, GPS tracked and faster than normal trials were 9.1 ± 0.99 ; 12.2 ± 0.92 ; 11.6 ± 0.84 and 13.3 ± 0.82 respectively. Quantified, this shows that, on average, the participants demonstrated very light exertion on the slower than normal trial, light and towards somewhat hard exertion on the normal and GPS tracked walks and for the faster than normal trial, the exertion was perceived as somewhat hard.

Three participants did not reach 1.34 ms^{-1} in their GPS tracked walk and one participant

did not reach a pace of 1.34 ms^{-1} on their normal walking pace trial. These four participants all walked at a pace of 1.33 ms^{-1} in their respective trials. Thus, every participant reached a pace of 1.34 ms^{-1} in at least one of the normal paced trials (GPS tracked and normal 150 m pace). The participants' mean GPS tracked walking pace was $1.52 \pm 0.20 \text{ ms}^{-1}$. This is 13.4% (0.12 ms^{-1}) above the minimum pace required for moderate intensity PA. Mean pace from the normal pace trial was $1.63 \pm 0.23 \text{ ms}^{-1}$; 21.6% (0.29 ms^{-1}) above the minimum pace.

A single-factor, within-subjects, repeated measures ANOVA indicated a significant difference between the mean paces of the four trials ($p < 0.05$). Pairwise comparisons showed that the mean differences between paces at each of the four walking instructions were also significant ($P < 0.005$). The difference between GPS tracked pace and 'normal pace' was 0.106 ms^{-1} ($P = 0.042$) (95% confidence intervals 0.003-0.209).

There was a strong positive correlation between GPS walking pace and height (0.806 , $P = 0.005$, R^2 value = 0.65), indicating that 65% of the variance in 'GPS walking' pace was related to the participants' height. For normal walking pace, a weaker non-

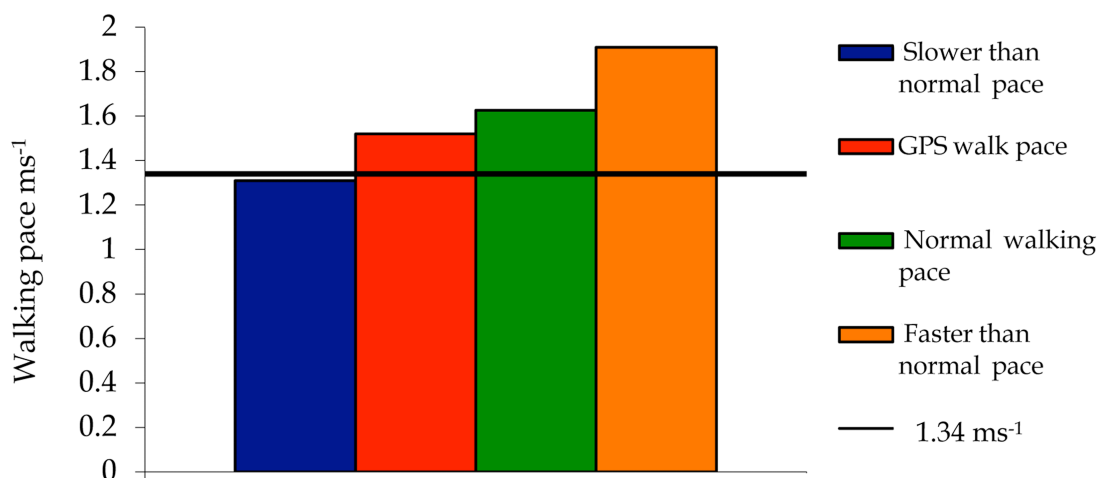


Figure 1- Participants' mean walking paces over the four trials, compared to that required for moderate intensity physical activity. (Black line represents the minimum recommended pace for moderate intensity (1.34 ms^{-1}))

significant association (0.617 , $P=0.058$, $R^2=0.38$) was found. There was also a weak negative association between percentage body fat and GPS walking pace (-0.582 , $R^2=0.34$), but this too was not significant ($P=0.077$). No association was shown between either GPS walking or normal walking pace and the variables of age, weight, BMI or average daily step count.

The mean GPS tracked pace for males ($n=3$) was $1.71 \pm 0.25 \text{ ms}^{-1}$ and $1.44 \pm 0.13 \text{ ms}^{-1}$ for females ($n=7$). An independent t-test produced a t score of $t(8) = 2.295$, $P=0.051$ (95% confidence intervals -0.00131 to 0.53464), thus suggesting that the male participants' GPS tracked pace was not significantly different from the female participants. The mean normal pace for the males ($n=3$) over the 150 m time trials was $1.81 \pm 0.28 \text{ ms}^{-1}$ and $1.55 \pm 0.17 \text{ ms}^{-1}$ for the females ($n=7$). This produced a t score of $t(8) = 1.888$, $P=0.096$ (95% confidence intervals -0.05920 to 0.59443). Therefore, the male participants did not walk at a significantly different pace to the female participants for the normal pace 150 m time trial either.

Subjective Assessment of Themes

The emerging themes provoked different responses among the participants and the sexes. Only the female participants highlighted footwear as a possible influence, where four agreed that wearing high heels slowed their walking down. Ground surface was the most commonly cited influence on pace with nine of the participants agreeing that pace increased when walking on concrete and decreased on grass. Three participants perceived a negative mood to increase their walking speed, two of whom went on to suggest that if they were walking and in a good mood their pace would decrease.

The weather theme demonstrated the most conflicting views between the participants.

Half of them felt the weather had no effect on their walking pace. However, three participants cited the wind as a factor which decreased their pace, and two reported that rain slowed them down. Conversely, three participants reported that cold temperatures increased their pace, two felt a decrease in pace when walking in sunny conditions and two participants reported that walking in the rain increased their walking speed.

DISCUSSION

The key finding of the present study was that all of the participants achieved a moderate intensity pace during either the GPS tracked or 150 m normal pace time trial. The mean GPS tracked ($1.52 \pm 0.20 \text{ ms}^{-1}$) and normal walking pace ($1.63 \pm 0.23 \text{ ms}^{-1}$) were comparable to findings of Murtagh et al. (23). Our observed pace were slower than the speeds reported by Spelman et al. (29); however, this was expected however, as they used young 'exercise walkers'. In the present study, participant's $\text{VO}_{2\text{max}}$, or HR_{max} were not assessed so it is not possible to speculate whether the participant's walking paces were associated with cardiovascular fitness (5).

In contrast with previous research on walking pace (13, 24), in the GPS tracked walk, males did not walk significantly faster than females. However, this finding should be treated with caution as there were only three male participants in the study, compared to seven females and the small sample size may have influenced the results. Therefore, due to the limitations in the sample size, a firm conclusion cannot be drawn on the impact of gender on the GPS tracked walk. Pace differences between males and females in the normal pace trial did not significantly differ. Although this may also have been influenced by the small sample size, it is likely that this observation is indeed correct. GPS tracked pace was

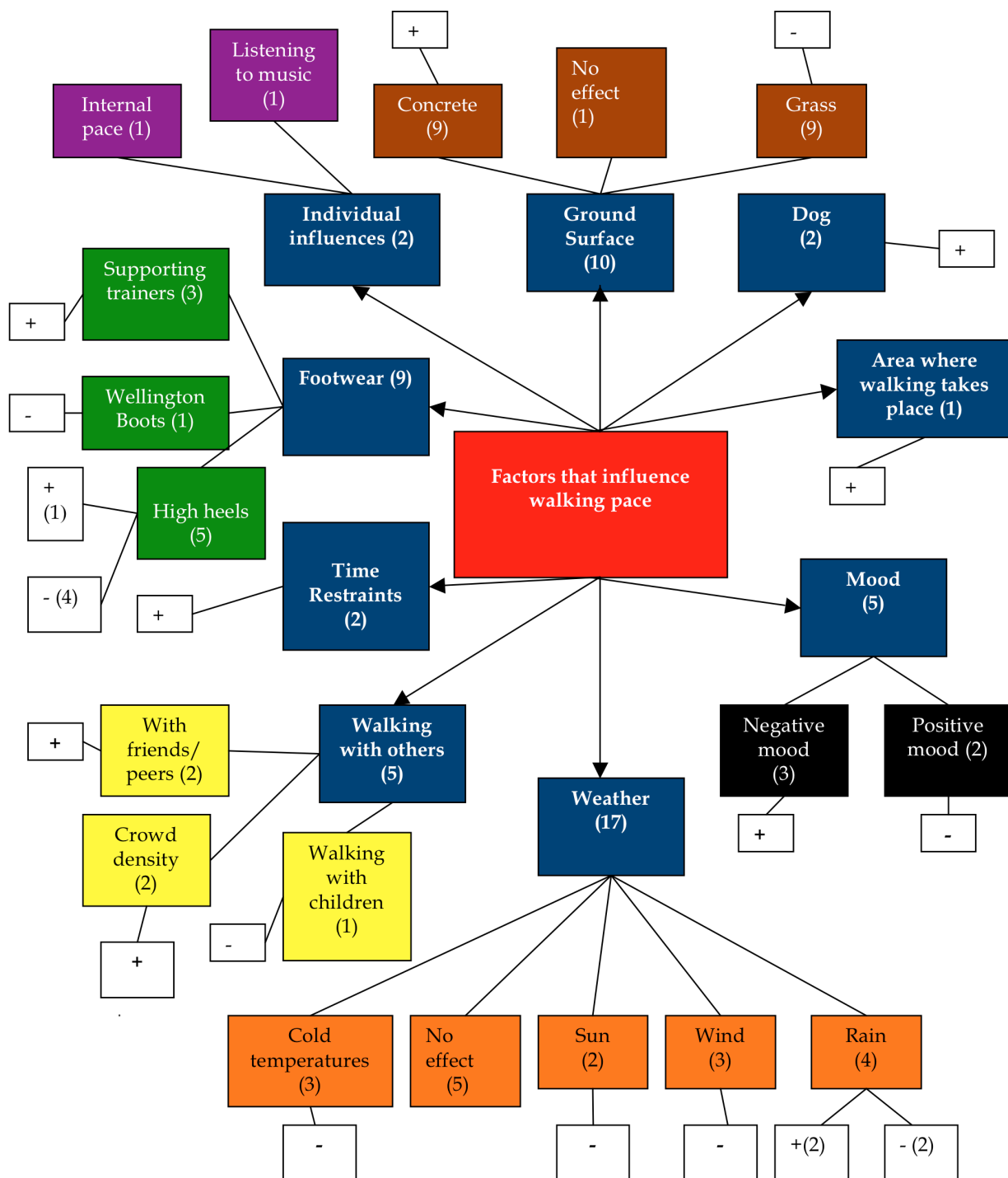


Figure 2- Spider diagram displaying the nine themes and specific influences on the participants' walking pace. The larger navy boxes represent the main nine themes. The number inside the boxes indicates the number of participants' views on the theme. The other colored boxes represent specific influences. The number inside the smaller boxes displays the number of participants' views on a specific influence within a theme. The symbols (-) and (+) indicate whether the influence decreases (-) or increases (+) walking pace.

faster than normal pace, which demonstrates the participants' inability to accurately select their own normal pace. An observation bias could also be attributed to the pace difference, as participants completed the GPS tracked walk unobserved, whereas they were watched during time trials. Additionally, this finding may highlight that it is not relevant to compare an individual's 1 km walking pace, where they will be walking continuously for a prolonged period of time, to a pace which they are only required to sustain for 150 m.

In agreement with previous findings (13), we found a strong positive relationship between GPS tracked pace and body height. A significant portion of the variance in GPS tracked walking pace was accounted for by height (~65%). When body height and normal walking pace were compared, the relationship was not as strong (~38% of variance). Based on our findings, it is reasonable to speculate that height may only be a factor over long, but not short walking distances. Also, height influences stride length and step frequency, which may explain the observed changes (34). These measures were not made in the present study, which is a limitation. No association was shown between either GPS tracked or the normal time trial pace and age, weight, BMI, and average daily step count. With regard to age, this contrasted with earlier findings (9, 13), however this may be due to a smaller age range in the present study (54 ± 8 y). Previous work has compared the walking speeds of younger and older people. For example, the study by Hinman et al. (13) assessed the walking pace of individuals aged 19-102 y, and Fitzsimons et al. (9) compared the walking speeds of women aged 20-23 and 75-83 y. Our finding of no correlation between both body weight and BMI with normal walking pace is consistent with what others have reported (4).

Through analysis of the participant's interviews, specifically the responses to question four, nine themes emerged. Consistent with Thorpe et al. (32), two participants acknowledged that their pace increased when they walked their dog due to the need to match the dog's walking pace rather than a slower, self-selected pace. We categorized the walking with others theme into two codes: 1) walking with friends/peers and 2) walking with children. Two participants reported their pace increased when walking with friends/peers, which is contrary to finds from other investigators (8, 16). Knoblauch et al. (16), reported that individuals walk faster alone rather than in company and Finnis and Walton (8), who observed no difference in pedestrian's pace when walking alone or with others. A plausible explanation for the findings in the present study was likely related to the participants' perception that they were slowing others down, which is why they increased their pace.

Environmental conditions also play a key role in mediating walking pace. The premise that the energy cost and pace of walking can be negatively influenced by an uneven outdoor terrain (25) was supported by the current study, where nine of the ten participants commented that their pace decreased when walking on grass and increased on concrete. The participants universally reported that their pace on grass decreased due to fear of injury or slipping. Half of the participants viewed weather to have no influence on their walking pace. No previous research has focused specifically on weather, so we are unable to fully determine its effect or lack of effect. Within the group of participants who did consider the weather to influence pace, there were conflicting views. For example, some participants reported that walking in the rain decreased pace, whereas others reported an increased pace.

There is insufficient evidence in the literature to fully substantiate our key environmental findings.

Weather influenced the participants in different ways, thus highlighting a possible limitation in the present study. Future studies should include methodology that measures and takes into account weather effects on walking pace. Additionally, although the weather may have influenced the participant's pace somewhat, one of the aims of the study was to assess normal walking pace in an outdoor environment, which includes variables that would be impossible to replicate in a laboratory. Other study limitations included the small and female-biased nature of the sample.

In summary, the present study has demonstrated that regardless of walking condition all participants walked at a pace that would be consistent with moderate intensity physical activity. Interpretation of this finding suggests that participants tended to self-select an appropriate pace and may be associated with health benefits of physical activity. The influence of weather on walking pace needs more examination in future studies. Finally, the utilization of the GPS device to determine the participant's pace demonstrated the enormous potential of this technique, as it enabled participants to walk freely, unobstructed and unobserved during testing, factors of which could not be replicated within laboratory settings.

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